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TRENDS AND PERSONALITIES IN SOVIET BRIDGE CONSTRUCTION

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Before the Revolution, Russian construction thought had already achieved certain trends and traditions, especially in the field of bridge construction. The schools, first of Professor Belelyuskiy, and then of Professors Proskuryakov, Paton, and Perederiye, should be mentioned in this connection. However, these schools were all static. The sole object of all their investigations was the analysis of structural forms. The sole argument was weight.

Trends in the field of building structures were even less clear. The small scale and unimportant nature of construction hampered the growth of an independent school. Most work was an imitation of methods, without independent analysis and improvement of a given design. Academician Shukhov, Professor Mitinskiy, and a few others offered the only creative work in this field.

In 1918, the Scientific Experimental Institute of the NKPS (People's Commissariat of Transportation) was founded. This was soon renamed the Higher Scientific Engineering Committee of the NKPS.

Experimental work was the keynote of the new era. Analysis and experimentation were combined, raising the scientific value of research.

The Scientific Experimental Institute of the NKPS naturally devoted its attention to transportation construction, i. e., bridges.

Two basic problems were attacked: the study of the dynamic strain on a bridge structure from the standpoint of the distribution of impact of live loads, and the study of the static load on the span structure, fundamentally from the standpoint of the strain on an extended span girder and the interaction of its parts. These problems have both been prominent from that time.

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The investigations on dynamics were done by a statistical analysis of railroads and motor-vehicle bridges under various types of loads. A series of auxiliary coefficients and rules for their conversion were obtained. These coefficients and rules characterized the dynamic load of bridges (Rabinovich, Il'yasevich, Gibshman, etc.).

Experimental study by means of special impact tests of the damping of vibrations in bridge structures was undertaken in the USSR earlier than in any other country (Rabinovich, Il'yasevich, Nikolaev, and others). The Soviet investigations received recognition as an established method, upon a report given by Professor Streletskiy at the International Bridge Congress in Vienna in 1928.

Further development and deepening of dynamics research continued in the 1930's, embracing even motor-vehicle bridges. This was the work of Gibshman and the DORNII (Highway Scientific Research Institute) Bridge-Testing Station. However, attention was also turned to the confirmation and elaboration of various standard specifications (Maksimov, Kazey, etc.).

Dynamics research was extended to building designs in 1927 with the opening of the All-Union Construction Institute, later renamed the TsNIPS (Central Scientific Research Institute of Industrial Construction).

Investigation of iron roofing of weaving mills, embracing the dynamic effect of the weaving machines on the roofing, research into the effect of crane loads on plant structures, and into the dynamics of crane bridges should all be mentioned (Engineers Kikin and Boguslavskiy).

From the very beginning, the Scientific Experimental Institute of the NKPS conducted statistical research into structural loads, in particular, those of bridges. Thanks to these investigations, much material was secured concerning the distribution of forces on structural elements. The dependence of the distribution of forces upon the loads of the adjoining elements of a structure was further clarified (Yevgarfov, Maksimov, Lyalina, etc.). The finishing touches to these questions were given by the work of Professor Paton, now an Active Member of the Academy of Sciences, Ukrainian SSR, entitled "The Experimental Bridge of the Kiev Bureau of the TsIS, NKPS," published in 1931.

The study of the problem of subsidiary forces on girder joints was also intimately related to this field of research. Although this problem, after study was seen to be of lesser significance than had been thought, it had nevertheless attracted much attention. Its definitive solution was given in another work of Professor Paton and his group, "Subsidiary Forces of Bridge Girders," published in 1930.

The study of the optimum structural form of bridges was another trend of construction thought in this period. Study of the weight of bridges, as a basic index of optimum form, was a continuation of older Russian tradition (Streletskiy, Kachurin, Bram, etc.). The creation of new structural forms for bridges in advance of specific requirements was another part of this trend. These new forms included the guy girder (Professor Rabinovich), the concrete-filled tubular arch bridge, special types of welded bridges, etc.

However, at that time, improvement of bridge forms was, for the most part, realized in another connection. In the reconstruction period, the necessity of calculating technical characteristics while evaluating a structural form began a modern Soviet tradition in bridge construction, sharply opposed to the old haphazard methods of construction (operations of the Bridge Bureau of the NKPS). Economy of material was a primary consideration. Even so, design and construction of bridges remained substantially unchanged.

Bridges of other types should be mentioned for this period. Beside suspension and guy bridges, there are the magnificent arch bridges in Zaporozh'ye, for example, the one across the Staryy Dnepr (Professor Streletskiy). The Gor'kiy Bridge (Professor Il'yasevich) and the Metro Bridge (Engineer Polikarpov) were the first bridges planned to realize the advantages of factory construction. Finally, a number of projects connected with the bridging of the Moscow River are related to this period. There was the design by Professor Streletskiy of the first single-span welded bridge -- to the Palace of the Soviets. Then there were suspension and arch bridges actually constructed, the work of Engineers Vakhurkin, Kalmykov, Konstantinov, etc. The Kostroma and Saratov railway bridges were constructed across the Volga with new cantilever-girder spans, more than 200 meters in length. The idea of using higher quality steel in bridge construction was strongly proposed by Professor Streletskiy at the end of the 1920's. This steel was used in the Zaporozh'ye, Metro, and Moscow River bridges, but not in railway bridges.

The first technical specifications for steel bridge designs were drawn up in 1928. These served as the basis for all subsequent specifications, in both bridge and industrial designs. The problem of the coefficient of safety was attacked by experimental methods which gave rich statistical data (Professor Streletskiy). This idea has only recently gained acceptance.

Soviet steel construction, lacking traditions and experience, was unable to satisfy the requirements of the First Five-Year Plan. Intensive construction and research, accompanied by study of foreign and domestic construction, resulted in new, more appropriate structural forms. A new Soviet school of construction emerged, based upon the solution of two leading problems: (1) conservation of metal, and (2) reduction of the labor used in construction work. Simplification of all structures was also sought.

Structural types were changed in accordance with these principles. Standard structures, especially girders and columns, were introduced. Ties guaranteeing three-dimensional rigidity of industrial structures were developed. Dimensions were reduced and simplified. These measures attained the desired results.

The daring and independence of Soviet construction thought was shown by the wide utilization of welding in construction in this period, when it was still in the experimental stage, and when there were not yet any established models of welding construction.

Beginning with the first Stalin Five-Year Plan, the search for new structural forms was inaugurated, as was wide utilization of planning and experimentation. Steel frames for the widest variety and sizes of industrial plants were made. Welding was widely employed.

The analytical approach to industrial construction problems was simplified by the previous work in the field of bridges. The first law of weight of industrial structures was established in this manner (Professors Streletskiy, Baldin, Vakhurkin, etc.). Organizations concerned with industrial structural forms were consolidated in an industrial-designing system, Stal'most, later named Stal'konstruktsiya (Steel Construction), and were thus brought very close to production, with favorable results.

This trend, a complex approach to the development of structural forms, was outlined by Streletskiy in his "New Ideas and Possibilities in Steel Structures" (1934) and in Engineer Mikhaylov's "Industrialization of Steel Structures" (1939). This trend was also realized in the operations of Promstroyproyekt (Industrial Building Design), KTIS, Stal'konstruktsiya, NKPS, and other organizations.

The Palace of the Soviets was planned in this period. Difficult constructional problems were overcome by Engineers Nasonov, Dzerzhkovich, etc. Structural computions were solved by Professor Segal. Actual construction work on the Palace of the Soviets gave impetus to research on high-quality steel (Academician Baykov) and the durability of structures (Professor Kornoukhov).

Experimental studies on optimum structural forms progressed parallel to analytical research. The work of TsNIPS -- of Golenko, Stelmakh, Semenov, and others -- should be mentioned, as well as that of A. N. Gendyrev and Belen' (research using models) and of Bernshteyn and and Kikin (study of the actual operations in plants).

In the experimental study of welding, the work of the Electric-Welding Institute, Academy of Sciences, Ukrainian SSR, under the leadership of Active Member Paton should be noted. Also deserving mention is the work of Vologdin and Rykalin in Vladivostok, of Duchinskiy, Nikolayev, Rykalin, and others in Moscow, and of Professor Okerblom and his school in Leningrad, all engaged in studying the construction possibilities of welding and its uses. Gibshman, Il'yasevich, and Shapiro should be mentioned for their work on riveted joints.

After 1934, the task of reviewing norms and specifications on the basis of the new experimental data was set, since the first "Norms and Technical Specifications for Design of Steel Structures" (KOMSTO norms) and the norms of 1930 and 1934 were all based on the "Technical Specifications for Bridge Design," which had little experimental foundation. In connection with this task, several problems were considered: plastic deformation in steel structures (Zhudin, Turkin, Bernshteyn, Malament, Gorbunov, etc.); rigidity under central and noncentral longitudinal pressure, and also the rigidity of girders and columns (Kurayev, Nikiforov, Dyatlov, Kornoukhov, etc.); and local rigidity (Braud). The new norms also incorporated features from earlier foreign and domestic specifications. Theoretical study of rolled designs was also undertaken.

In this period, thin-sectioned shafts and girders were introduced and studied (Professors Blasov, Dobudoglo, Bychkov, Shenfel'd). The problem of industrial manufacture of standard prefabricated steel structural units for industrial buildings was undertaken by Promstroyproyekt, Proyektstal'konstruktsiya (Steel Structures Design).

Bridge construction was stabilized in the 1930's. A general review of the structural forms of bridges was only suggested just before the war by Engineers Tikhonov and Orlov.

During the war, attention was directed to satisfying military needs. However, the behavior of steel structures after destruction and during reconstruction demonstrated the possibilities of increasing loads, and in 1942-1944 the coefficient of safety was reduced to the record figure of 1.36. This value, also supported by statistical investigation, permits economy of construction steel and labor. The problem of rapid manufacture of steel structures was also posed by the war. This led to simplification of structural forms, and wide employment of rolled sections in girders, columns, etc.

In 1943-1945, construction thought was preoccupied with the problem of reconstruction. The basic principles of such were: (1) economy of steel, (2) maximum re-use of elements of destroyed structures, and (3) wide utilization of electric welding. Structural forms were brought into closer correspondence with the problems of manufacturing them. Bridge construction was reorganized along these lines suggested before the war by Engineers Tikhonov and Orlov, finding expression in a series of standard span sections for railway bridges, which were developed by Proyektstal'-konstruktsiya (Engineer Popov).

These ideas also led to a review of the bases of the design of structural steel used in the construction of large objects, and to a transition from standard designs to construction from standard elements and parts. An attempt has been made to maximize standardization.

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